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Ceteris Paribus Laws: Generics & Natural Kinds

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PRACTITIONERS OF THE SPECIAL SCIENCES, such as psychology, biology, or geography, articulate generalizations that seem to differ in important respects from the laws that physicists present. Only the former tolerate exceptions, and we can mark this fact by saying that they are generalizations that hold other things equal, or *ceteris paribus*. These are the generalizations that are traditionally called cp-laws, though I'll argue below that this label is misleading.

CP-laws have played a prominent role in several debates in the philosophy of science, usually because there is unclarity, and hence disagreement, about what they say. Let me make this more precise. We can regiment statements of laws into the form *it is a law that p*. Initial discussions of laws of nature focused on analyzing the nomic operator *it is a law that*, trying to determine which claims, if true, are (or express) laws of nature.¹ To take one well-known example, one might want to know why *all uranium spheres are less than 100,000km in diameter* expresses a law, while the similar *all gold spheres are less than 100,000km in diameter* does not. In these examples, the content of the claim that is said to be a law is quite transparent, so we can focus immediately on what makes one but not the other a potential law. However, when *p* in the schema *it is a law that p* is replaced by a sentence containing the locution *ceteris paribus*, it is not at all clear what proposition is said to be a law.

This is reflected in the debates in which cp-laws have figured prominently. Two examples concern explanation and the nature of theories. In the case of explanation, opponents of the DN-account have argued that cp-laws are unsuited to appear in deductively subsuming explanations, but that the special sciences nonetheless are capable of offering serious explanations of the phenomena they study.² In the case of theories, opponents of the view that theories are, or are properly modeled by, deductively closed axiomatic systems have argued that cp-laws are

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1. See, e.g., Armstrong (1983); Hempel (1965); Lewis (1973b); Nagel (1979); Van Fraassen (1980, 1989).
 2. See, e.g., Dray (1957) and Rosenberg (2001a,b).

unsuited to enter into the deductive relations that this view would require of them.³ In both cases, it is a problem about the deductive relations cp-laws enter into, and thus about the proposition said to be a law, that animates the debate.

For this reason, much of the debate about cp-laws has focused on the question how we should characterize the relevant generalization. The main burden of this paper is to make a two-fold contribution to this literature, one methodological, the other more directly substantive. I will argue that in stating the relevant generalizations, practitioners of the special sciences make use of a linguistic resource familiar from ordinary language, specifically, genericity. We can thus make progress on understanding cp-laws by appealing to the semantics of natural language at several crucial junctures. That is the methodological aim. More substantively, I will focus on one kind of genericity we can use in stating *some* cp-laws, what I'll call *characterizing sentences*, and give their truth-conditions. On my proposal, the cp-laws we state using characterizing sentences are very closely connected to the natural kinds of the discipline in which they are articulated. I'll argue that on this proposal, we can account for several important aspects of these cp-laws, some familiar, some new.

I'll begin by delimiting the aims of this paper more precisely in §1. I then turn to the debate between Pietroski and Rey (1995) on the one hand and Woodward (2002) on the other, which will serve as a jumping off point for my own account (§2). §3 is devoted to making the connection between cp-laws and natural language more precise and to focusing on the more specific target of analysis for the rest of the paper. §4 introduces and motivates the view of natural kinds I will appeal to and explains their relationship to characterizing sentences.

Throughout, I won't take a stand on whether we should take cp-laws to be genuine laws. My concern is exclusively with getting clear on the broadly semantic issues. To mark this fact in my terminology, I'll discuss what I'll call *cp-generalizations*. A cp-generalization is a sentence

3. See Giere (1988a,b, 1999) and Cartwright (1983, 1989, 1995, 1999).

that can take the place of *p* in the regimentation *it is a law that p*, and when it does, the instance of the schema expresses a purported cp-law.

1. CP-Generalizations: Some Problems

I have so far spoken of an unclarity about what a cp-generalization expresses. In order to focus the investigation, we need to sharpen the intuitive sense of puzzlement into more precise issues. This is particularly important for me since the account I will offer is non-reductive. In order to evaluate whether it succeeds, I need to say just what its aims are. In this section, I introduce two of them, and then situate my account in relation to the most common way of stating the problem of cp-generalizations. §2 introduces a third phenomenon to be accounted for.

The most striking feature of cp-generalizations is the fact that they tolerate exceptions. The exceptions to a cp-generalization are cases that are compatible with that generalization's truth, but which would refute the corresponding universal generalization. Exceptions contrast with counterexamples to the cp-generalization which are incompatible with its truth.

A natural, albeit unsuccessful, way of trying to say what a cp-generalization means appends a clause headed by *unless* to a universal generalization derived from the cp-generalization. An example will help to make the point. We might begin with (1).

- (1) *Ceteris paribus*, all ravens are black.

(1) does not have the same force as the corresponding universal generalization *all ravens are black*, since (1) is true, while the simple universal is false, as witnessed for example by albinos. A more promising attempt at saying what (1) amounts to without helping ourselves to the *ceteris paribus* locution is (2).

- (2) All ravens are black, unless they are albinos.

However, (2) does not capture the force of (1) either, since ravens that are non-black because of the environmental conditions they experi-

ence, rather than the genetic endowment they are born with, would falsify (2) without intuitively leading us to reject (1). And it seems as if, for any way of adding more qualifications to the unless-clause, we can come up with more mere exceptions we have not yet captured. Let's call such an unless-clause *open-ended*, and let's call the cp-generalization that gives rise to such an unless-clause *open-ended*, as well.⁴ Of course, there are some ways of listing the exceptions that does not result in an open-ended unless-clause. We could say that ravens are black unless they are abnormal. By itself, this does not represent any advance beyond (1). But if we do not help ourselves to these expressions, the list of merely apparent exceptions is open-ended.

This observation suggests that we won't make progress on saying what a cp-generalization means simply by listing exceptions. It also introduces the first phenomenon to be accounted for: why are cp-generalizations open-ended, and what unifies the apparently heterogeneous class of a cp-generalization's exceptions?

Let me add another striking feature that is not usually discussed, but that is also concerned with the contrast between exceptions and counter-examples. The point is easiest to state with respect to the contrast between cp-generalizations and straightforward universal generalizations. The former, but not the latter, are insensitive to small changes in the way the world is. (1) is true in the actual world, and it would still be true if there happened to be one or a few more non-black ravens than there actually are. By contrast, a true universal generalization *all As are Bs* would be false if there was an extra *A* that was not *B*. In order to find a pair of worlds such that a cp-generalization is true with respect to one, false with respect to the other, the two worlds need to differ in very significant respects. For example, a world that clearly falsifies (1) is a world in which ravens have evolved to have the color scheme of Crimson Rosellas.

4. The problem concerns the *potential* exceptions to the generalization. Even if at some point only black ravens exist, (1) still poses the same problem, since it *would not* be falsified by certain non-black ravens.

CP-generalizations also contrast with other run-of-the-mill generalizations, such as ones of the form *most As are Bs*. The truth-value of such a claim is, in many cases, robust with respect to adding a single *A* that is not *B*. That most students are under forty years old would remain true even if there was another student over forty. However, *As* that are not *Bs* are all potential counter-examples to the majority claim. The robustness of the truth of the claim derives from the fact that we need enough counter-examples in order to falsify it. By contrast, a cp-generalization *ceteris paribus, all As are Bs* that is true in the actual world would not only remain true if there was an extra *A* that wasn't *B*, that extra *A* would simply be another exception. The very status of an *A* that is not a *B* as exception or counterexample depends on larger patterns in the world. This gives us our second explanandum: why is the truth of cp-generalizations only sensitive to large-scale changes?

I want to end this section by situating my account with respect to the way the problem of cp-generalizations is most commonly stated in the literature. Many theorists argue that the open-endedness of cp-generalizations threatens them with triviality.⁵ A generalization is non-trivial if there could be counterexamples, i.e., if there are circumstances that would falsify it. But since the list of exceptions to a cp-generalization is open-ended, anything could be covered by that list. In that case, there couldn't be any counterexamples (not even potentially), making the generalization trivial. That is the *triviality worry*. Applied to my example, it says that (1) amounts to no more than *all ravens are black, unless they aren't*.

The triviality worry is by far the most important point of debate in the literature on cp-generalizations. A subsidiary one focuses on epistemic considerations, concerning the claim that cp-generalizations

5. Pietroski and Rey (1995, 87) give a prominent statement. Woodward, who argues that there is a significant problem with cp-generalizations, cites this passage as stating the problem (Woodward, 2002, 308). Other authors who also take triviality to be the main problem include: Earman and Roberts (1999), Earman et al. (2002), Fodor (1991), Mott (1992), Schiffer (1991), Schurz (2001, 2002), and Silverberg (1996).

cannot be empirically confirmed or disconfirmed.⁶ Any observed case that does not conform to the generalization, no matter what, could potentially be counted among the exceptions because there are no significant constraints on them. That makes an “honest test” impossible. But this is really just the triviality worry again. Both turn on the idea that there are no constraints on the exceptions. The concern about confirmation stands and falls with the triviality worry, and I won’t discuss it separately here.

Since I aim to give semantics for at least some cp-generalizations on which they are non-trivial, I implicitly respond to the triviality worry, as well. However, I want to be explicit about one respect in which I do not so much answer that worry as assume that it is baseless. As will emerge in §4, the account I offer is non-reductive. Thus, someone who takes the triviality worry to not just show that we need to understand cp-generalizations better, but that they might be fundamentally defective and hence must be elucidated by offering a *reductive* semantics, will find my account unsatisfying. The notions I appeal to will strike such a theorist as requiring as much explication and defense as cp-generalizations did in the first place. Against this demand for a reductive account of cp-generalizations, one couched only in terms that are better understood by some relevant standard, I want to anticipate a point I will argue for later. CP-generalizations are often, and most naturally, stated using natural language, and in general, demanding reductive semantics for natural language is an unreasonably high bar to set.

2. Pietroski & Rey vs. Woodward

Pietroski and Rey explicitly address the triviality worry in their (1995), but much of what they say is a substantive theory of cp-generalizations. In discussing their view I pursue two aims, one positive, one negative. On the positive side, I want to highlight a basic motivating thought that I agree with: cp-generalizations reflect the needs

of theorizing in sciences that investigate complex phenomena. I’ll also show that their view goes some way towards illuminating the striking features I just mentioned, since it offers a ready account of the open-endedness of cp-generalizations. However, I’ll argue on the negative side that their view faces some important shortcomings. First, it does not offer an account of why the truth-value of cp-generalizations is only robust with respect to small-scale changes, not large scale ones. And second, I’ll point out various semantic relations among cp-generalizations, relations of compatibility and incompatibility, that their account does not capture, but that a more complete semantics for cp-generalizations needs to handle. This discussion will set the stage for the rest of the paper.

2.1 The View

Pietroski and Rey introduce their view thus.

[S]cientists state cp-laws in an attempt to focus on particular factors (e.g., natural selection) and thereby ‘carve’ complex phenomena (e.g. the evolution of populations) in a theoretically important way.⁷

The idea that a theoretically important carving of the phenomena a scientific discipline investigates is at the heart of the practice of using cp-generalizations is one that I want to pursue, as well. It obviously needs to be spelled out, and here is the next step Pietroski and Rey take.

Our own view is motivated by the following general consideration: the emergence of any theoretically interesting science requires considerable abstraction and idealization. The actual world is too complex to study all at once, so one proceeds by ignoring some aspects of the world in order to understand others. We idealize away from friction,

6. See for example Earman et al. (2002, 293) and Schurz (2002, 360-2).

7. Pietroski and Rey (1995, 92).

electric charge, and nuclear forces, for example, when we seek to understand the effect of gravity on the motion of bodies. However, such abstraction guarantees a loss of descriptive adequacy in any generalization we lay down, since actual bodies are always affected by, e.g., friction, at least a little.⁸

Let me connect these remarks to the concrete semantic proposal. In the first instance, Pietroski and Rey do not wish to give truth-conditions for cp-generalizations. Rather, they want to state a condition that, if satisfied by a cp-generalization, ensures that it is non-trivial. However, the two tasks are not really separate, since a cp-generalization is non-trivial just in case its truth-conditions cannot be satisfied trivially. And that means that, in stating a non-triviality condition, Pietroski and Rey state a necessary condition on the truth of a cp-generalization.⁹

As the quotes make clear, Pietroski and Rey couch a lot of their discussion in terms of examples from simple physics, such as ideal gases. I'll make use of a similar example, that of springs, but the points generalize. The relevant cp-generalization about springs states that the period of a spring depends on the mass of a suspended object m and a spring-constant k according to a simple formula, captured in this generalization.

$$(3) \text{ (} Ceteris\ paribus \text{), all springs have a period determined by } T = 2\pi\sqrt{\frac{m}{k}}.$$

There are conditions under which (3) fails to accurately describe the period of a given spring: the mass might be subject to friction-forces, or it might, if made of iron, be subject to a magnet placed in its vicinity to either increase or decrease its period. Nonetheless, one might think, the generalization (3) gets at something important. And at any rate,

8. Pietroski and Rey (1995, 89).

9. They go on to make some passing remarks about how to strengthen the condition to be sufficient, as well. I'll indicate that below.

whatever qualms one may have about calling (3) a *law*, it does not seem to be a triviality.

Here, according to Pietroski and Rey, is the relevant feature that accounts for its non-vacuity, and the non-vacuity of other acceptable cp-generalizations. Certain cases covered by the generalization, i.e., certain springs, conform to it. Other cases, i.e., other springs, do not. In the latter cases, however, we can explain why any given failure to conform to (3) is a failure by citing one or more factors that do independent explanatory work. To put this in terms of the examples I've already mentioned, if the period of a spring fails to conform to (3) because the massive object is made of iron and subject to a magnetic field, then we've explained (or at least can explain) why that particular spring fails to conform to (3) by citing the magnetic field. Appeals to that magnetic field do independent explanatory work, such as explaining why a compass-needle in the vicinity turns in a particular direction.

More generally, a cp-generalization is non-vacuous if the following is a necessary condition for its truth: all exceptions to the generalization can be explained away citing only independently motivated causal factors.¹⁰ To see how this condition works to exclude a putatively true cp-generalization whose acceptability quite clearly has been bought at the price of trivialization, consider (4) about ESP.

$$(4) \text{ (} Ceteris\ paribus \text{), on all occasions on which Jones tries to divine the future, she is successful.}$$

Faced with a non-conforming case, i.e., Jones' failure to see the future coming, the proponent of (4) might explain away the failure by citing a factor that does no independent work, such as psychic static. If she countenances any such kinds of interferences, (4) is trivialized. Then again, she might only cite factors that do independent explanatory

10. See Pietroski and Rey (1995, 92) for their more elaborate statement of the view. There, they seem to suggest that this condition might be sufficient, as well. One of the upshots of the argument below is that it cannot be sufficient.

work, such as sunspots or migraines. In that case, the putative cp-generalization may not be trivialized, but simply false if it turns out that sunspots or migraines don't actually explain the failure.

Pietroski and Rey do a lot to give an account of what independent explanatory work amounts to, but I will simply grant them the notion, since the points I will make now do not rely on any controversial way of interpreting it.

2.2 *Interference, Causation, and Open-Endedness*

I'll begin by showing that implicit in the view of Pietroski and Rey is an explanation for why cp-generalizations are open-ended in the sense of §1. To make this more obvious, I'll say a little more about how the particular account they provide is related to the programmatic remarks I quoted at the beginning of this discussion.

As they say there, cp-laws reflect idealizations. In very many cases, an idealization of a situation we're investigating is a simplified version of it.¹¹ Most importantly, the idealization will contain far fewer causal factors than the original situation. In the idealization, these factors are the only ones involved in bringing about an effect. Given this understanding of idealizations, we might put the connection between cp-generalizations and idealizations like this. A cp-generalization about a kind of thing—springs, for instance—is true iff there is an idealization that takes into account some of the factors potentially acting on things of that kind, and in the idealization those factors bring about the state of affairs described by the generalization, and in some members of the kind, these causal factors exhaust the causally relevant ones. This is why, in a non-trivial cp-generalization, we can always explain why an

11. Obviously, this is not supposed to do justice to the wide range of things one might call an idealization in the sciences, let alone the closely related notion of a model. But I trust that the description in the text is true of an important subclass of idealizations. For at least some other things that are reasonably counted among idealizations or models, see Mäki (2002); Morrison and Morgan (1999).

exception occurs by citing an independent causal or explanatory factor. An exception occurs only if a particular situation contains causal factors that differ from those in the idealization. That's why we can point to these factors to explain the occurrence.

Recall now that cp-generalizations are open-ended if the list of merely apparent exceptions is heterogeneous and open-ended. If Pietroski and Rey are right, then this is unsurprising. A mere exception, i.e., something that falls short of a counterexample, arises because a causal factor operates on a member of the kind mentioned in the generalization that differs from those countenanced in the underlying idealization and thus forces that object to behave in a way that doesn't conform to the generalization. But the form that such causal influences can take are legion, and they need not have anything in common except that they make the object deviate from the course predicted by the underlying idealization.¹²

2.3 *Woodward's Charges*

I now want to raise some questions a semantic theory for cp-generalizations should answer that the account of Pietroski and Rey leaves open. I'll argue that many cp-generalizations satisfy the necessary condition on their truth, but are nonetheless false. In fact, we can discern patterns of incompatibility among these generalizations, and an adequate semantics needs to predict these patterns. Given the lim-

12. By linking cp-generalizations to idealizations, we can account for another feature of cp-generalizations. They exhibit what we may call deviant conformers: members of the kind at issue that satisfy the predicate of the generalization but do so in a deviant way. Put in terms of my example regarding springs, a spring might have a period described by $T = 2\pi\sqrt{\frac{m}{k}}$, but do so because a number of disturbing factors happen to cancel each other out. Though the spring is in a high-friction medium, the oscillating object is accelerated by an outside force to counter the effects of friction. Intuitively, such a case falls outside of the scope of the cp-generalization about springs. We have a ready explanation of this fact if we assume that the cp-generalization is closely tied to a particular idealization. The one to which the cp-generalization about springs is tied presumably countenances neither the high-friction medium nor the external force.

ited aims of Pietroski and Rey, this is not an objection. It is, rather, a reason to look further.

The necessary condition Pietroski and Rey impose is essentially existential. In order for a cp-generalization to be non-trivial, it is sufficient that *there is* a suitable idealization. And in general, existential claims are compatible with other existential claims about the same things. Hence, for any idealization, there is a corresponding non-trivial cp-generalization. Return to the example of springs. In *some* springs, the relevant causal and explanatory factors are exhausted by the weight of the massive object and the spring constant, and in those cases, the period is given by the formula in (3), which is why (3) is true. In some *other* springs, the relevant causal and explanatory factors include those two and others besides, such as the presence of a magnetic field with a particular strength and orientation. In those cases, a different formula applies, call it T' . Consider the corresponding cp-generalization (5).

(5) (*Ceteris paribus*), all springs have a period determined by T' .

The intuitive judgment here is two-fold. (5) is false. More importantly for my purposes, (3) and (5) are incompatible, at most one of them can be true. Even more strikingly, we could turn (5) into a truth by qualifying which springs the generalization applies to, as in (6).

(6) (*Ceteris paribus*), all springs with iron bobs in such-and-such magnetic fields have a period determined by T' .

The pattern of incompatible cp-generalizations that can be saved by appropriate qualification is quite general, as (7) and (8) illustrate.

- (7) a. (*Ceteris paribus*), all ravens are black. (true)
b. (*Ceteris paribus*), all ravens are white. (false)
c. (*Ceteris paribus*), all albino ravens are white. (true)
- (8) a. (*Ceteris paribus*), if the price of a good falls, demand for that good increases. (true)
b. (*Ceteris paribus*), if the price of a good falls, demand for that good falls. (false)

- c. (*Ceteris paribus*), if the price of a good falls and the price of a substitute good falls even more, demand for that (initial) good falls. (true)

I think that this observation is also what fundamentally makes Woodward's influential example about charged particles work. He considers (9).

(9) (*Ceteris paribus*), all charged objects accelerate at $10m/s^2$.

And he goes on to say:

For every charged object, there is an additional condition K (having to do with the application of an electromagnetic field of appropriate strength to the object) that in conjunction with the object's being charged is nomically sufficient for its accelerating at $10m/s^2$. [...] for those charged objects that do not accelerate at $10m/s^2$, there is always an explanation that appeals to some other factor K' for why this is so—K' will presumably have to do with the fact that the object in question has been subjected to an electromagnetic field (or some other force) of the wrong magnitude to produce this acceleration. In addition, since classical electromagnetism is a powerful, non ad hoc theory, K' will figure in the explanation of many other facts. [...] Even more alarmingly, parallel reasoning can be used to show that "All charged particles accelerate at $n\ m/s^2$ " is a *ceteris paribus* law for all other values of n .¹³

I especially want to draw attention to the end of this quotation. It is the fact that, as far as Pietroski and Rey's account enables us to see, each of the generalizations of the form (10) is true that is the real concern.

(10) (*Ceteris paribus*), all charged particles accelerate at nm/s^2 .

13. Woodward (2002, 310).

Thus, what is really problematic about Pietroski and Rey's account is the fact that it does not furnish the resources to distinguish the true from the false instances of this schema. They all satisfy the non-triviality condition. This way of diagnosing the problem with the account has some significant advantages over Woodward's original presentation. Woodward wants to simply conclude that the sentences of the form (10) cannot all be cp-laws. But this conclusion doesn't allow us to distinguish two potential sources of the difficulty. The problem could either be that the generalization said to be a law (*ceteris paribus* or *otherwise*) is false, or the problem could be that the generalization, though true, fails to be a law. Given that both of these options are live, it's not clear where to lay the blame for the failure of any instance of (10) to be a cp-law.

By contrast, if the problem is about the consistency of various statements, we know where to lay the blame. The generalizations said to be laws cannot all be true together, so the problem is quite independent of any issues regarding the nomic operator.¹⁴ This way of diagnosing the problem also casts a different light on a discussion by Pietroski and Rey in a similar context. They consider the concern that on their view, it looks as if any true singular causal claim entails a corresponding cp-law.

Every singular causal claim of the form A caused B—e.g., Alice's favorite event caused Betty's most hated event—is a candidate for an interferable cp-law, since the quantifier might range over all the conditions that prevent As from bringing about Bs in all other cases. So far as anything we

14. An anonymous reader for this journal suggested that perhaps an intuition about lawhood is behind this example, after all. On this diagnosis, what's troublesome about the set of instances of the schema (10) is the fact that, if they were all laws, the system of laws would be too complex. However, this alternative diagnosis cannot account for the fact that the generalization becomes acceptable once the subject term is appropriately qualified, as in the examples (7) and (8). If the problem were with the complexity of the laws, we'd expect it not to vanish when we qualify the subject term.

have said, there *might* be a cp-law ' $\text{cp}(A \Rightarrow B)$ ' to the effect that, cp, Alice's favorites cause Betty's hates; it is just that *cetera* have been *paria* only *once* in the history of the world, and, moreover, are not easily made so. However, we are not committed to regarding ' $\text{cp}(A \Rightarrow B)$ ' as a bona fide law, but only to claiming that, given that the singular claim is true, the corresponding CP law cannot be criticized for being *vacuous*.¹⁵

I take it that similarly, Pietroski and Rey would say that the problem with Woodward's schema (10) is that these claims, though acceptable generalizations, fail to be laws, i.e., that it is the job of the nomic operator to explain why the instances of (10) are unacceptable as cp-laws. But if I am right in saying that the problem is at bottom one about consistency, not the nomic status of the generalizations, then this reply is insufficient. We're missing something fundamental about the semantics of the generalizations said to be laws by being unable to capture obvious inconsistencies among them.¹⁶

The upshot of the discussion is therefore mixed. On the one hand, we've seen that thinking about cp-generalizations in terms of causal processes or mechanisms is very appealing, because it allows us to give a convincing account of the open-endedness of cp-generalizations—one of the features that needs to be explained. On the other hand, we don't have the right way of spelling out that connection, because we cannot capture consistencies and inconsistencies. Incidentally, we also lack an account of why cp-generalizations change their truth-value in response to large-scale, but not small-scale changes in the way the world is. In the case of Pietroski and Rey, the problem takes the form of not being able to explain why even large-scale changes in the way

15. Pietroski and Rey (1995, 98–9).

16. Incidentally, in the linguistics literature, a very similar account to that of Pietroski and Rey has been developed by Cavedon and Glasbey (1994), drawing on work in Barwise (1993) and Barwise and Seligman (1994). Their account suffers from identical drawbacks.

the world is should falsify a cp-generalization. As I've argued, on their view, cp-generalizations are in the first instance claims about the existence of certain idealizations, and whether such idealizations exist is completely independent of what the world is like.

We are thus left with the following explananda: why are cp-generalizations open-ended? Why do they change their truth-value only in response to large-scale changes in the way the world is? And: how can we account for the semantic relations of consistency and inconsistency among them? Answering the last question should also help us see why we can save otherwise false cp-generalizations by appropriately modifying their subject terms, e.g., why *ravens are white* is false but *albino ravens are white* is true.

3. Targeting the Analysis

I have so far gone along with the practice of speaking relatively indiscriminately about cp-laws and cp-generalizations as if these formed a unified class amenable to a unified treatment. However, I think that Woodward is clearly right when he says that there is a

great diversity and heterogeneity [to] the generalizations that philosophers propose to analyze in terms of the category *ceteris paribus* laws.¹⁷

That means that any theory of generalizations in this area needs to have a more sharply defined range of phenomena as its subject matter. A natural first thought is that what is special about cp-generalizations is the presence of a certain locution in their statement, to wit, *ceteris paribus*. But as Schiffer and Woodward both point out, that phrase is hardly ever employed outside of economics.¹⁸ We thus need some other means of singling out the target phenomena and carve them up into unified classes.

17. Woodward (2002, 305). Hall (2005) makes a similar observation.

18. See Schiffer (1991, 10) and Woodward (2002, 305).

3.1 CP-Generalizations and Generics

I suggest that we turn to natural language to do that job. Let me introduce a class of linguistic phenomena that linguists and philosophers of language study under the heading of *generics*. The term derives from the intuition that very often, we speak about kinds—genera—and say something about them. In some cases, we seem to speak of a kind as a whole, as when we say that *quartz is widespread* or *dodos are extinct*. However, some generics behave exactly like statements of cp-laws in the sciences, such as *ravens are black* or *turtles are long-lived*. These sentences are compatible with what would be counter-examples to the corresponding universal generalizations, just as cp-generalizations are. They also have what linguists often call a law-like flavor, which is to say that their semantics have modal import. We can bring this out by observing that their truth is compatible with at least some situations in which the corresponding existential generalization would be false. *Ravens are black*, for example, is true even in a situation in which all ravens have been painted.¹⁹ That means that the truth-value of such a generic doesn't just depend on the state of the world of evaluation at the time of evaluation, but on what is true at other worlds and/or times, i.e., on modal facts. They also exhibit the same open-endedness and contrast between large- and small-scale changes as the cp-generalizations paradigmatically discussed in the literature.

To a good first approximation, I thus want to claim that such generics are used to state very many cp-laws. More specifically, if we continue to regiment the statement of cp-laws into the form *it is a law that (ceteris paribus) p*, many cp-laws can be, and are indeed most naturally, stated by removing the *ceteris paribus* locution along with any explicit quantifiers and replacing the schematic variable *p* with a generic sentence. (11) illustrates this connection by way of some examples.

19. Perhaps one would like to respond that, *in the relevant sense*, the ravens are still black when they're painted white, taking inspiration from Austin (1975) and, following him, Travis (1985, 2000). However, the point still holds: *lions have four legs* can be true even in a situation in which all lions have lost one of their legs in accidents.

- (11) a. It is a law that (*ceteris paribus*), all slow rivers meander.
 b. It is a law that (*ceteris paribus*), all grass is green.
 c. It is a law that (*ceteris paribus*), if the price of a good falls, demand always rises.
 d. It is a law that (*ceteris paribus*), iron bars always expand when heated.

Removing *ceteris paribus* and the explicit quantifiers leaves us with generalizations that have the same features.

- (12) a. Slow rivers meander.
 b. Grass is green.
 c. If the price of a good falls, demand rises.
 d. Iron bars expand when heated.

Just as importantly given the concerns I've raised in §2.3, we see the same pattern of incompatibilities, as (13) and (14) illustrate.

- (13) a. Ravens are black. (true)
 b. Ravens are white. (false)
 c. Albino ravens are white. (true)
 (14) a. If the price of a good falls, demand for that good increases. (true)
 b. If the price of a good falls, demand for that good falls. (false)
 c. If the price of a good falls and the price of a substitute good falls even more, demand for that (initial) good falls. (true)

So if we want to understand cp-generalizations, we need to focus not on the locution *ceteris paribus*, but on the rest of that statement.

3.2 Characterizing Sentences

The class of generics is very broad, and it is simply impossible to do justice to that class as a whole. For that reason, I'll focus my inquiry more narrowly on a class of sentences that I'll call *characteriz-*

ing sentences.²⁰ These are sentences that express a non-strict generalization over members of a kind and that have the modal component I've pointed to.²¹ Because I'm restricting myself to generalizations over *members of a kind*, I won't discuss so-called *habituals*, such as the examples in (15).

- (15) a. Mary smokes.
 b. Dogs bark.

(15a), for example, says more than that Mary has, on at least one occasion, smoked, but it also does not say that she smokes at all times. Rather, we can get at what (15a) is after by interpreting it as a generalization over events that involve Mary, claiming that some appropriate subset of these events are ones in which Mary smokes.²² (15b) mixes generalizations over objects and events and is therefore non-strict twice over. It is both a characterizing sentence and a habitual: a characterizing sentence because it does not apply to all dogs since it doesn't range over dogs without vocal tracts, and a habitual because it does not say that all events involving the remaining dogs are barking events. I want to emphasize that my restriction to characterizing sentences is therefore quite substantive, since it excludes ascriptions of dispositions (ascriptions of properties such as being fragile), and it excludes many statements involving explicit mention of the verb *cause* because these ascriptions are usually couched in terms of habituals.

20. Here, I follow Krifka et al. (1995), which has done a lot to standardize the terminology in the field.

21. I thus set aside sentences that predicate a property of a kind as a whole, such as *quartz is widespread*, and merely existential sentences such as *ravens are sitting on the wires outside my house*.

22. This is an idea that traces back to Davidson's discussion of action sentences in Davidson (1980), and from there has become a central plank in what has become known as *neo-Davidsonian* semantics, the view that all sentences, not just action sentences, contain quantification over events in their logical form. One of the early applications of this idea to ascriptions of dispositions is Lewis (1973a). For a more recent elaboration, see Fara (2001, 2005).

The kind of proposition that is expressed by a sentence such as *ravens are black* can be expressed in several different ways, aside from the bare plural I just used. One could also use a singular definite or singular indefinite article, i.e., *the* or *a*, as in *the raven is black* and *a raven is black*. Nonetheless, I'll focus on sentences with bare plural subjects.²³ In some cases, a sentence is ambiguous and can express two different generic propositions, such as the famous *typhoons arise in this part of the Pacific*, which can be used to express either that this part of the Pacific is where typhoons arise—they only exceptionally arise elsewhere—or that this part of the Pacific is regularly subjected to typhoons, although typhoons also arise elsewhere.²⁴ The first of these propositions is the kind I'm after. Since none of the examples I'll discuss exhibit this ambiguity, I'll ignore it from hereon.²⁵

3.3 *Semantics for Characterizing Sentences*

The strategy now is to present enough of empirically motivated semantics for characterizing sentences to allow me to account for the puzzling features of cp-generalizations I've collected. The semantics

23. One reason for this preference is that plurality seems to be a basic ingredient in genericity, and apparently singular subjects are nonetheless interpreted as having some features of plurality. We can see this by noting that certain predicates that can usually only be applied to pluralities can appear in generic sentences with singular subjects. For example, ordinarily we can predicate *form a circle* or *surround* only of pluralities, as the contrast between *the children formed a circle* and **Mary formed a circle* shows. However, many speakers find *the buffalo forms a protective circle* completely acceptable.

24. The example is due to Milsark (1974).

25. Woodward suggests that sometimes, we can use such bare plural sentences to express nothing more than statistical generalizations, citing such as examples as *drivers in England drive on the left* (Woodward, 2002, 311). Officially, I can be agnostic on whether it's possible to use bare plurals to express such a pure regularity, saying only that bare plurals, when so used, fall outside the purview of my theory. But as a matter of fact, I disagree with Woodward's characterization of the data. I think what's really at issue is whether this kind of generalization is, or can be, part of a systematic theory and hence deserves the title of *law*, as Woodward seems to acknowledge at (Woodward, 2002, 311).

I present will, at least initially, be formulated in terms of a primitive notion of normality. I'll then try to show that the special sciences naturally provide the resources to relate that notion to the demands theories in these disciplines face, especially demands that arise from the complexity of the phenomena they investigate. In this way, my view represents an alternative development of the guiding principle that cp-generalizations reflect the needs of theorizing about complex phenomena.²⁶

Following a lot of work in this area, I will assume that the intuitive sense that characterizing sentences express generalizations over the members of the kind mentioned is basically accurate. The question is what kind of generalization that is.²⁷ A first pass at an answer is this.

26. In providing truth-conditional semantics, I'll take on commitments large and small that I can only acknowledge here. First is the commitment that giving truth-conditions is the right way to give the semantics of natural language in general, or generics in particular. Opponents have cited generics in arguing for alternative semantic frameworks. In the literature on linguistics and philosophy of language, see Chomsky (1975), Leslie (2007, 2008), Schubert and Pelletier (1989), and Veltman (1996). In the literature on philosophy of science, some theorists have suggested that we shouldn't interpret cp-law statements as expressing propositions, but in some other way, perhaps as inference rules, as in Lange (2000). For another alternative, see Glymour (2002). One of the reasons theorists often give for rejecting ordinary truth-conditional semantics is that while it's possible to give somewhat plausible semantics for simple cases, it is extremely hard to show how they can be extended to more complex examples in a theoretically motivated and compositional way. This will be true of the semantics I present here, as well. This is, in the first place, a concern about the viability of a research program, the program of fitting semantics for characterizing sentences into the overall truth-conditional framework. The right way to pursue this point is to see whether the research program yields interesting results in some core cases in order to determine whether it's worthwhile to try to develop it further.

27. For some reasons to prefer such a quantificational approach to the truth-conditions of characterizing sentences, see Cohen (1999), Krifka et al. (1995). I have also argued for it in Nickel (2008). One reason to adopt the quantificational approach is that we can account for the availability of two readings of *typhoons arise in this part of the Pacific*.

FIRST PASS TRUTH-CONDITIONS

As are F is true iff all normal *As* are *F*.

The point of this first step is to take into account the fact that characterizing sentences tolerate exceptions: tolerable exceptions are not normal, and hence do not falsify the characterizing sentence.²⁸

We need to make these semantics slightly more sophisticated, a move that can be motivated by considering the pair of sentences in (16).

- (16) a. Chickens lay eggs.
- b. Chickens are hens.

If we interpreted (16a) as saying that all normal chickens lay eggs, and (16b) as saying that all normal chickens are hens, then we would predict that (16a) entails (16b), since all chickens that lay eggs are hens. However, that entailment clearly does not hold. The most plausible way to block it is to say that when we interpret generics, we never interpret them just by asking about what is normal *per se*. Rather, we are always concerned with what is normal in this or that respect, and the respect of normality is determined by the predicate in the generic.

28. One might worry about potential counter-examples at this stage.

- (I) a. Dutchmen are good sailors.
- b. Mosquitos carry plasmodia (the organisms that cause malaria in humans).

(Ia) is not well paraphrased as saying that all normal Dutchmen are good sailors, and (Ib) doesn't seem to be as strong as the claim that all normal mosquitos carry plasmodia. After all, (Ib) is true in the actual world, even though only a minority of mosquitos actually carries the organisms, and that minority doesn't seem particularly normal. Suffice it to say that there are responses available. Cohen (1999) and Krifka et al. (1995) suggest that (Ia) involves a different reading of the bare plural. And the acceptability of (Ib) may well be due to the fact that the sentence is ambiguous. The acceptable reading might be the one that is a characterizing sentence about plasmodia, to the effect that all normal plasmodia are carried by mosquitos (as part of their normal life-cycle). This isn't the end of the debate, obviously.

On this strategy, (16a) says not that all normal chickens lay eggs, but rather, that all chickens that are normal with respect to how they extrude offspring lay eggs. By contrast, (16b) says that all chickens that are normal with respect to their sex are hens. These paraphrases are such that we no longer predict (16a) to entail (16b). In fact, we predict the intuitively correct truth-values, since on this paraphrase, the latter is false.

We need to complicate the semantics still further to account for the examples in (17) and (18).

- (17) a. Bears live in North America.
- b. Bears live in South America.
- c. Bears live in Europe.
- d. Bears live in Asia.
- (18) a. Elephants live in Africa.
- b. Elephants live in Asia.

In these cases, the respect of normality is the same—normal in respect of habitat. Applying the current semantics would predict that each bear that is normal in this respect lives on four continents, which the examples in (17) obviously do not entail. The best way to deal with examples like this is to introduce ways of being normal and allow the truth-conditions to explicitly quantify over them. Thus, the examples in (17) might be paraphrased by the corresponding ones in (19).²⁹

- (19) a. There is a way *w* of being a bear that is normal with respect to its habitat, and all bears that are normal in way *w* live in North America.
- b. There is a way *w* of being a bear that is normal with respect to its habitat, and all bears that are normal in way *w* live in South America.

29. I've argued in detail that introducing such ways of being normal and quantifying over them brings significant empirical benefits. See my (2008).

- c. There is a way *w* of being a bear that is normal with respect to its habitat, and all bears that are normal in way *w* live in Europe.
- d. There is a way *w* of being a bear that is normal with respect to its habitat, and all bears that are normal in way *w* live in Asia.

As these paraphrases make clear, there is no reason to think that any of the examples in (19) can be put together with any of the others to derive unwanted conclusions about the habitats of individual bears, since being a bear that's normal in one of the ways does not entail anything one way or another in regards to being a bear that's normal in some other way. More generally, then, the truth-conditions for characterizing sentences that I want to work with are these.³⁰

SEMANTICS FOR CHARACTERIZING SENTENCES

As are F is true iff there is a way *w* of being an *F*-normal *A* such that all *As* that are normal in way *w* are *F*.

Here, *F*-normal is short for *normal in a respect determined by the predicate F*. And I want to emphasize that the property I pick out by *normal* is not necessarily the property picked out by the ordinary English word *normal*, it is a placeholder for a property to be elucidated in the next section. That means, in particular, that I do not predict *ravens are normal ravens* to be a truth, let alone a necessary one.

30. Incidentally, here the locution *ceteris paribus* seems to make a genuine semantic contribution to sentences in which it appears. When one prefaces a characterizing sentence with *ceteris paribus*, that sentence is true only if it mentions all of the ways of being normal in the respect at issue in interpreting that sentence. Thus, (IIa) is true while (IIb) is false.

- (II) a. *Ceteris paribus*, elephants live in Africa and Asia.
- b. *Ceteris paribus*, elephants live in Africa.

But aside from this quirk, *ceteris paribus* does not seem to have any semantic impact on the interpretation of characterizing sentences.

These semantics do not yet incorporate the modal element that accounts for the law-like flavor of characterizing sentences. We can add it simply by introducing a counterfactual element to the truth-conditions, as illustrated for a particular example in (20).

- (20) a. Ravens are black.
- b. There is a way of being a normally colored raven such that, if there was a raven that was colored in that way, then all ravens that would be colored in that way would be black.

In those cases in which there is a relevantly normal raven, the truth-conditions (20b) just collapse into the semantics I've highlighted, so I'll ignore this counterfactual element.

As the statement of the semantics make clear, the only so far unexplained primitive notion is that of normality. More specifically, we need to complete the biconditional in (21).

- (21) *x* is an *A* that is an *F*-normal *A* in some way *w* iff ...

The task of the next section is to develop the resources to do just that.

4. Complex Phenomena: Causal Homogeneity and Unification

Different scientific disciplines appeal to different properties in order to formulate their respective theories. Given that these different disciplines investigate different phenomena, this is unsurprising. Different categorizing schemes will serve different investigative aims better or worse. The question I want to address is this: what makes a scheme of classification the (or a) right one for a given discipline? This is one question we can ask by asking what the natural kinds for a given range of phenomena are.

That question is distinct from various other metaphysical and linguistic issues that arise in the context of natural kinds and natural kind terms. I am not, at least in the first instance, concerned with the question whether there are any objective divisions among phenomena, where groupings that correspond to such objective divisions

form a natural kind while gerrymandered groupings do not. Nor am I concerned with the question whether, assuming that there are natural kinds, the naturalness of natural kinds is a basic feature of the world, or whether that naturalness can be reduced to something else.³¹ I will not ask about the connection between natural kinds and essential properties, either, for example, whether it is true that if an object belongs to a natural kind, that is an essential property of that object. Finally, I will not address the semantics of natural kind terms. I will remain silent, for example, on whether descriptivism is true as a metasemantic theory of such terms, and on whether natural kind terms retain a constant meaning or a constant reference across even substantial changes in theory.³² These are all important questions, but my discussion can hopefully proceed while remaining neutral on all of them. I need to register only one *caveat*: I will appeal to causation in making theoretical claims. To the extent that such appeals carry commitments on the issues I just mentioned, I won't remain neutral on them. However, the notion of causation seems sufficiently basic to think that any theory of science has to be compatible with broad appeals to it.

The question then is this: what are some of the desiderata that a property should meet if it is to be useful for couching theories of a particular domain? In broad outline, the answer to that question is clear. Practitioners of a discipline want to appeal to those properties that allow them to formulate systematic and powerful theories.³³ The more

specific claim I want to make here is that there are at least two such desiderata, which I'll call causal homogeneity and unifying power. I'll then argue that, in any science that investigates complex phenomena, these two demands are in tension, and the resolution of the tension furnishes us with the resources to explicate the notion of normality I appealed to in my semantics.³⁴

To impose some order, I'll assume that each discipline, at least at a given time, has a range of phenomena it seeks to investigate and theorize about. Geography, for example, investigates the shape of the Earth's surface, the distribution and shape of rivers, and so on. Evolutionary biology investigates the myriad ways in which organisms fit into their environment and how the species to which these organisms belong evolve. I'll call these the discipline's *target phenomena*. At least one important aim of theorizing is to formulate generalizations about the shape these target phenomena actually take, for instance, generalizations about what shape rivers are, and what colors various species are. The general structure is well captured in terms of determinable and determinate relations. We can think of target phenomena in terms of properties such as the property of having some shape or other and the property of having some coloration or other, and we can think about the generalizations as telling us which determinate of that determinable is actually instantiated, such as which shape rivers actually have, and which color scheme members of a kind actually have.

31. For citations about these issues, see the updated bibliography in Bird and Tobin (Winter 2008).

32. That is, I'll be silent on whether Kripke (1972) and Putnam (1975a,b) are right about natural kind terms.

33. Many theorists who endorse this general principle in fact hold a more specific version, one that is particularly keyed to *explanatory* power. Thus, for example, Kitcher: "Natural kinds are the sets that one picks out in giving explanations. They are the sets corresponding to predicates that figure in our explanatory scheme." (Kitcher, 1984, 315n11) Similar remarks can be found in Platts (1983, 134), LaPorte (2004, 19), Rieppel and Kearney (2007, 97), and Root (2000, S629). Wilson (1996, 307), a review of Dupré (1993), makes the point that the issue of pluralism about species turns on whether there are different disciplines that are equally legitimate but require different classificatory schemes in order to achieve their aims, thus endorsing my

claim, as well. Boyd (1991, 1999a,b) and philosophers following him, such as Kornblith (1993) even go so far as to suggest that a theory of natural kinds just is a theory that addresses the question I'm asking.

34. In this discussion, I do not want to presuppose that any scheme currently employed actually meets these desiderata. Indeed, changes in such categorizing schemes are the results of investigation as much as anything else, and thus represent genuine progress. But that doesn't mean that we cannot ask about the desiderata that practitioners try to meet more and more successfully as they adapt their categorizing schemes to the phenomena they study.

4.1 *Causal Homogeneity*

My first constraint grows out of the informal suggestion that generalizations in scientific disciplines should map out the causal structure of the domain under investigation. There are several reasons theorists have given for endorsing this claim. One is broadly epistemological. On this strategy, we appeal to causation to explain what makes a hypothesis projectible. Roughly, the reason that *all emeralds are green* is projectible while *all emeralds are grue* is not is that the former reflects the causal structure of the world in a sense to be made more precise.³⁵ A second strategy begins with broadly explanatory considerations. If the generalizations of a discipline are to play a role in causal explanation, they have to correspond to the causal structure of the world.³⁶ The third strategy focuses on practical considerations. If we want generalizations to guide our interventions in the phenomena the sciences investigate, these generalizations need to furnish causal information about the world.³⁷

The informal notion of a generalization's corresponding to or mapping the causal structure of the world needs to be made more precise in order to be useful in theorizing. I suggest that we do so by requiring that generalizations in the sciences be causally sustained. A generalization of the form *all As are Bs* is causally sustained iff all *As* are *B* and in all of the cases in which the properties of being an *A* and being a *B* are coinstantiated, that coinstantiation is the result of the same causal mechanism. In this sense, the generalization *all gold melts at 1948°F* is causally sustained.

What makes the notion of a causally sustained generalization a good candidate for explicating what it means for a generalization to correspond to or map the causal structure of the world is the requirement that the mechanism that accounts for the coinstantiation of the

two properties be the same in all of the cases in which that coinstantiation occurs. That is what crucially distinguishes causally sustained from merely accidental generalizations. In the accidental ones, it is true that for every case in which the properties are coinstantiated, there is a causal mechanism that accounts for it, but it is not the same in all cases.

At this point, one might have two concerns about the thesis that all generalizations in the sciences should be causally sustained. First, one might worry that the notion of a single causal mechanism isn't well-defined, because we can individuate causal mechanisms any way we want. For that reason, any given case in which an *A* is a *B* instantiates indefinitely many mechanisms if it instantiates any, and depending on which of these mechanisms is at issue, a generalization either will or will not count as causally sustained.

The concern is reasonable as far as it goes, and it would be debilitating if there were no further constraints on how we should individuate processes. I want to contend, however, that there are such further constraints, because whether a generalization is causally sustained should be evaluated within the context of a particular discipline. This is important because distinct disciplines have proprietary ways of individuating mechanisms. We can see this quite clearly in discussions of supervenience. It is commonplace to describe one manifestation of multiple realizability by saying that one and the same mental process can be realized by several, very different neural, biological, or chemical processes. That description presupposes that these different disciplines have their own ways of individuating types of mechanisms. This response to the concern has the consequence that a generalization may count as causally sustained by the lights of one discipline but not by the lights of another. I take this to be a favorable result, since it seems to harmonize with one prominent way of understanding what the autonomy of higher-level disciplines amounts to: being able to recognize commonalities among phenomena invisible to lower-level

35. See, e.g., the papers by Boyd and Kornblith cited in note 33, as well as Millikan (1999).

36. See, e.g., Salmon (1984, 1989) and Strevens (2004).

37. See, e.g., Woodward (2003).

disciplines.³⁸

Even granting that the notion of a single causal mechanism is well-defined within the context of a discipline, one might worry that the requirement that there be a single mechanism is too strong. Perhaps it is enough that there be a small number of processes that jointly sustain a generalization. However, even when the discipline in the context of which a cp-generalization is articulated recognizes a multiplicity of processes, it usually also recognizes these multiple processes as belonging to a higher type. Let me briefly discuss an evolutionary example.³⁹ Populations of *E. coli* bacteria evolve very rapidly. Subjected to an environment that is low on a particular nutrient, such as glucose, such populations evolve to become more efficient at using the reduced nutrients. They can accomplish this by various different genetic paths, a fact that shows up once the evolved populations are subjected to other nutrient-deprived environments. Some of the populations that are good at using glucose are not very efficient at using fructose, while others are. The structure of the example is thus that at one level of description, there are several causal mechanisms that underwrite the efficiency of *e. coli* at utilizing glucose. At another level of description, there is just one. And quite plausibly, the context in which we want to formulate generalizations about the adaptability of *e. coli* to nutrient-deprived environments are ones in which the particular genetic basis of the change doesn't matter.

Given that we want *generalizations* to be causally sustained, we can also draw a conclusion about a desideratum for the *properties* we mention in these generalizations. If a generalization of the form *all As are*

Bs is to be causally sustained, then the predicate *A* in such a generalization needs to have in its extension only objects that are involved in the same causal mechanism with regards to whether they are in the extension of *B* or not. When that is the case, we can say that the *As* are causally homogeneous with respect to whether they are *B* or not. More explicitly:

CAUSAL HOMOGENEITY The property of being an *A* is causally homogeneous with respect to whether *all As are B* iff all *As* are involved in the same causal mechanism in determining whether they are *B*.

For example, the property of being gold is causally homogeneous with respect to the generalization *all gold melts at 1948°F*.

Thus, we have good theoretical grounds for saying that a property is a natural kind for a discipline only if that property is causally homogeneous with respect to the universal generalizations that discipline seeks to articulate. The example of natural kinds in the fundamental sciences certainly satisfy this condition.⁴⁰ However, this condition fits awkwardly with the special sciences, and indeed it is awkward twice over. In the first instance, the special sciences do not seek to articulate straightforward universal generalizations, though I've suggested that in fact, the cp-generalizations they do articulate are restricted universal ones. More importantly, it does not seem as if it is a goal to formulate predicates that denote causally homogeneous classes, though that would clearly be possible. For example, if we focus not simply on all of the ravens, but on ones that go through a particular developmental process *D*, we would have a property that is causally homogeneous with respect to *all ravens that go through D are black*. But we do not see a predicate that picks out such a homogeneous class. In this respect, the situation is precisely the reverse of the one encountered in the fundamental sciences. There, practitioners adjust the extension of

38. This response goes only part of the way towards a resolution of the worry since it is a substantive question how to individuate disciplines. For one, simply identifying disciplines as finely (or coarsely) as university departments—biology, chemistry, etc.—is too coarse. A discipline is rather marked out by the coherence between the target phenomena, research strategies, and evidential and explanatory standards. My account trades on the existence of disciplines thus picked out.

39. This example is discussed at length in Travisano et al. (1995).

40. The condition is also in line with Putnam's suggestion that natural kinds are explanatory kinds; see Putnam (1975a).

their predicates so that they can use them to formulate straightforward, causally sustained generalizations. In the case of the special sciences, practitioners retain the predicates and give up on the straightforward universal generalizations.

This pattern isn't restricted to biology by any stretch of the imagination. We see the same thing in geography. Consider being a river. The true generalizations about all rivers whatsoever seem to mostly mark constitutive connections, such as carrying water. In order to reach a causally homogeneous property, we need to focus on a more narrowly defined one. Being a river that runs through such-and-such soil and subject to such-and-such fluctuations in water level might be causally homogeneous with respect to *all such rivers meander*, but again, we do not see simple predicates that denote such a causally homogeneous property. To understand what's going on, I want to introduce the next desideratum for a natural kind property.

4.2 Unifying Power

One of the aspects of a theory that makes it systematic is its unifying power. Intuitively, a theory has more unifying power if it contains generalizations that connect many targets of inquiry. The crucial question is how to spell out the metaphor of connecting different phenomena via a collection of generalizations. One way to do so is to find a number of true universal generalizations that all agree on their scope but differ in their predicates. Newtonian mechanics paradigmatically exhibits this kind of connection. Bodies with a certain mass have many properties in common. Moreover, the demand that the natural kinds of that discipline be causally homogeneous harmonizes well with this way of cashing out the demand for unification. Its practitioners can attempt—and are at times successful—at satisfying both of these demands.

However, in the case of the special sciences, these two demands are fundamentally in tension. Suppose that we fix on a class of ravens R_1 that is causally homogeneous with respect to *all ravens in R_1 are black*.

R_1 will in turn not be causally homogeneous with respect to any other generalization. Not only is *all ravens in R_1 have two wings* not causally sustained, it's false. This is a non-accidental feature of the phenomenon under investigation, specifically of the mechanisms that could causally sustain a generalization. Most of these mechanisms can operate independently of each other. To see this point in an example, suppose that in addition to R_1 we focus on a class of ravens R_2 that is causally homogeneous with respect to *all ravens in R_2 have two wings*. The two classes R_1 and R_2 don't coincide, since there are winged albinos and black ravens that have lost a wing.

Let me now argue that this tension cannot be analyzed away in order to motivate my preferred resolution, introducing a different way of cashing out the metaphor of connecting phenomena. One might try to say that we can make the property denoted by the predicate *raven* causally homogeneous with respect to many different generalizations by intersecting all of the classes that are causally homogeneous with respect to at least one such generalization. For example, we might simply intersect R_1 and R_2 , yielding a class that is causally homogeneous with respect to both generalizations. One should then perform this operation for all targets of inquiry that we can formulate an acceptable generalization about.

There's something intuitively odd about this approach, since it would exclude many ravens from the extension of the predicate *raven*, but the intuitive oddity can be countered by thinking of *raven* as picking out the typical or paradigmatic ravens. We can object to the approach more sharply by pointing out that it is subject to a dilemma. Either we intersect *all* homogeneous subclasses, or we do not. If we do, we will at least sometimes end up with an empty extension. That's because we sometimes find sets of characterizing sentences that are all true but predicate incompatible properties, such as (22).

- (22) a. Lions have manes.
- b. Lions give birth to live young.

The class of lions that are causally homogeneous with respect to their

sexually selected head-dress and that can causally sustain (22a) excludes females; the corresponding class for (22b) includes only females. Hence, the intersection of these two classes is empty. On the other horn of the dilemma, we intersect only some causally homogeneous subclasses. In that case, we've added a bit of unifying power, since the relevant properties are causally homogeneous with respect to more generalizations, but it is still puzzling why there should be a single predicate that denotes different properties in different generalizations. We therefore cannot analyze away the tension between the demands of causal homogeneity and unifying power by manipulating the interpretation of the kind terms involved. Instead, we should reconceive what unifying power comes to in the special sciences.

The key innovation is two-fold, changing both the relata and the posited relation between them. Rather than focus on the kind terms that appear in the different generalizations (or the properties denoted by them), we should focus on the mechanisms that causally sustain them. And rather than require that the relation be one of identity, we should only require that the relation be theoretically important, given the demands of the discipline. Thus, a set of generalizations is unified if the mechanisms that causally sustain them are related in a theoretically important way.

One may worry, of course, that an appeal to a "theoretically important relation" among mechanisms deprives the account of any content it might otherwise have had. The apparent contentlessness of the notion is a result of the fact that I am trying to capture what is common to many disciplines, each of which determines what the theoretically important relations are empirically. *Within* a given discipline, the notion of a theoretically important relation among mechanisms has much richer content. In broadly evolutionary contexts, for example, the theoretically important relations are all either directly or indirectly the result of selection. For example, the presence of a developmental mechanism in the population of ravens that yields black ravens and the presence of one that yields two-legged ones are both the result of selection. In micro-economics, the mechanisms that are eligible to

underwrite a cp-generalization are all related to each other insofar as they all reflect the deliberation of an economically rational agent under budget constraints. In physical systems such as pendula, springs, and gases, the mechanisms are related by incorporating the minimal set of causal factors that are responsible for the distinctive behavior of these kinds of things, such as harmonic motion or an equilibrium between various properties.

This account doesn't yet explain why we see predicates like *raven* in the generalizations of the special sciences. To see that, I need to return to the semantics of characterizing sentences.

4.3 Normality

Our task is to complete the biconditional (21).

(21) *x* is an *A* that is an *F*-normal *A* in some way *w* iff ...

For now, I'll focus on the cases in which *A* is replaced by a simple noun, such as *raven*. I'll have more to say about how to explicate normality when it comes to modified nouns, such as *albino raven*, below. With this restriction in mind, I'll divide that task into three questions. Why should there be a restriction to a subset of *As* at all—why restrict ourselves to normal members of the kind in the first place? Why, given that there is such a restriction in the first place, does that restriction depend on the predicate—why do we need normality *in a respect*? And why are there sometimes several ways of being normal in that respect?

We need to restrict ourselves to a particular subset of the *As* in formulating a generalization about *As* because such a generalization should be causally sustained, and hence the class of objects the generalization is about should be causally homogeneous with respect to that generalization. As we saw in the previous section, for most choices of *A* and most generalizations, the whole class of *As* won't be relevantly causally homogeneous. Hence, we need to have a notion of normality.

We've also seen that due to the nature of the mechanisms that can causally sustain generalizations, these mechanisms can usually oper-

ate independently of each other. That is to say, the subsets of *As* that are homogeneous with respect to two different generalizations usually do not coincide. That in turn means that the subset needs to depend on the generalization we are considering. That is just to say that what counts as relevantly normal needs to depend on the predicate, which is why what is at issue is not just being a normal *A*, but being one that is normal in a respect determined by the predicate. Here, the notion of a target of inquiry is extremely useful: the respect determined by the predicate *just is* the target of inquiry of which that predicate denotes a determinate. For example, if the predicate is *black*, then the target of inquiry is coloration, and that is just the respect of normality determined by the predicate.

Finally, we can also account for the fact that at times, there are multiple ways of being normal, even once we fix on a particular respect. Suppose that we're thinking about a particular target of inquiry *T*, such as habitat. What makes an *A* normal with respect to *T* is the fact that it goes through a causal mechanism that determines which determinate of *T* this *A* has, together with the fact that this causal mechanism bears a theoretically important relation to other mechanisms for other targets. In the case of habitat, that may be that the presence of the mechanism is the result of an adaptation. But there may be several mechanisms that determine a value for *T* and that all bear the same relation, e.g., that are all adaptations. And that just means that there are multiple ways of being normal in the respect of *T*.

Let me summarize by completing the biconditional.

NORMALITY Assume that we are considering the characterizing sentence *As are F* with target of inquiry T_F . Then:

x is an *A* that is an *F*-normal *A* in some way *w* iff

- (i) *x* is an *A*, and
- (ii) *x* is involved in a mechanism *m* that determines that *x* has one of the determinates of T_F , and
- (iii) *m* stands in a theoretically important relation to mechanisms that determines that *x* or other *As* have determi-

nates of other targets of inquiry T_1, \dots, T_n .

Put in less complex terms, what makes an *A* relevantly normal is that it goes through a theoretically important mechanism for the purposes of a particular target of inquiry. And what makes the mechanism theoretically important is a relational feature, not an intrinsic one. We can now put this theory to some explanatory work.

For example, we can now explain why practitioners of the special sciences retain predicates like *raven*, rather than refining them in order to be able to use them in formulating straightforward universal generalizations that are causally sustained. If they did that, they would be stuck with a very large number of predicates that would appear to be unrelated and hence would not mark out that we are in fact capturing a significant connection among phenomena.

Drawing on the same resources, I now want to account for the three explananda I listed at the end of §2.3. Why are cp-generalizations open-ended, why do they change their truth-values in response, and only in response, to large-scale changes, and how do we account for the semantic relations we've observed?

Recall that a generalization is open-ended just in case the list of (mere) exceptions is open-ended. Given the semantics I've proposed, something is an exception to the characterizing sentence *As are F* just in case it is an *A* that is neither *F* nor *F*-normal. Since what makes an *A* relevantly normal is that it is involved in the (or a) theoretically important mechanism, an *A* is not normal if it is not involved in this mechanism, which is to say that it is an *A* that either never began the mechanism, for which the mechanism was derailed, or whose outcome was altered once it ran to completion. Each way of achieving such a deviation from the theoretically important mechanism will give rise to a kind of exception to the generalization. And since there are indefinitely many ways that the mechanism can be derailed, there are correspondingly many kinds of exceptions to a given generalization. For this reason, characterizing sentences are open-ended.

The account of the contrast between small scale and large scale change depends on a point about causal homogeneity I haven't drawn attention to so far. The causal mechanism or mechanisms that underwrite being an *F*-normal *A* are individuated, in part, by their end-points.⁴¹ Thus, in the example of *ravens are black*, the process that makes a raven a normally colored raven is one that a raven cannot go through without being black. This observation has the consequence that if it's true that *As are F*, then the process that makes an *A* an *F*-normal *A* (in some way) is such that all *As* that go through it are *F*. That in turn means that once we've fixed on the mechanism that makes an *A* *F*-normal, we've fixed the truth-value of *As are F*. There is no further variation once the mechanism has been fixed. This is the crucial point for understanding why a change in the truth-value of a characterizing sentence always requires large-scale changes.

In order for a characterizing sentence *As are F* to differ in truth-value when it's evaluated with respect to two different worlds, the mechanism that makes an *A* *F*-normal has to differ between the worlds. As I just argued, what makes a mechanism the one that certifies an *A* that is involved in it as *F*-normal is the fact that it bears a theoretically important relation to other mechanisms for other targets of inquiry. And whether a mechanism bears that relation can only change if there are large scale changes. For example, if we are dealing with a coloration mechanism that is normal in virtue of being the result of an adaptation, it can only cease to be the normal coloration mechanism if it is

no longer the result of an adaptation. And that requires a large-scale change.

We can also explain why we see the asymmetries I drew attention to in my discussion of Pietroski and Rey (§2.3). There, I noted that *ravens are black* is true and *ravens are white* false, even though there are mechanisms that underwrite appropriately restricted universal versions of each. Hence, the difference between these two characterizing sentences cannot be explained by saying that there only is a causal mechanism to underwrite the former. Rather, the difference consists in the relational features of these mechanisms. Only the one that sustains *ravens are black* is appropriately related to other mechanisms instantiated in the population of ravens, while the one that might sustain *ravens are white* is not.

The most interesting data, and the hardest ones to account for, concern the fact that we can turn the false *ravens are white* into a truth by appropriately qualifying the subject, as in *albino ravens are white*. Here are some of the facts we need to account for. First, *albino ravens are white* is a genuine cp-generalization. It tolerates exceptions and has modal import. It also exhibits asymmetries. It's false that *albino ravens are black*, even if there are a number of albinos that are all painted by a single mechanism, so that the latter generalization, too, is causally sustained.

What, then, differentiates the mechanism that leads to white albino ravens from the mechanism that leads to black albino ravens? If we tried to simply take over the account that I appealed to in order to explain why *ravens are black* is true but *ravens are white* is not, we'd be courting disaster. In that case, we would have to say that the reason that *albino ravens are white* is true is that the mechanism that sustains the generalization bears theoretically important relations to other mechanisms that causally sustain generalization such as *albino ravens have two legs*, *albino ravens have two wings*, and so on. But these mechanisms are the very same ones that causally sustain the corresponding generalizations about ravens, *simpliciter*. That, in turn, would entail that the mechanism that causally sustains the generalization *albino ravens are*

41. I assume determinism for the mechanisms that can sustain a cp-generalization, though not in general. This seems to reflect how we use these generalizations. We are extremely reluctant to describe an uncontroversially chancy process, even one that is very likely to issue in a particular outcome, with a categorical cp-generalization, as opposed to one that is explicitly about chances, likelihoods, or ratios among outcomes. Consider, for example, a coin and the generalization "tosses of this coin land heads." This generalization is unacceptable, even if the coin is quite heavily biased towards heads. A better way of describing the situation is "tosses of this coin tend to/usually land heads."

white bears theoretically important relations to the mechanisms that sustain *ravens have two wings* and *ravens have two legs*. And that would entail that the mechanism that leads to white albino ravens is eligible to certify a white albino raven as a normally colored raven, *simpliciter*, so that *ravens are white* is predicted to be true. That will not do.

Here is my alternative proposal. It crucially exploits the fact that we're qualifying the subject term of another generalization by providing a slightly different account of normality, one that is derivative from the account of normality appropriate to unqualified subject terms.

QUALIFIED NORMALITY Assume that we are considering the characterizing sentence *G As are F* with target of inquiry T_F , where *G* modifies the subject *A*. Then:

x is a *G A* that is an *F*-normal *G A* in some way *w* iff

- (i) *x* is a *G A*, and
- (ii) *x* is involved in a mechanism *m* that determines that *x* has one of the determinates of T_F , and
- (iii) *m* is just like a mechanism that determines that a *y* is an *F*-normal *A*, compatibly with the fact that *x* is a *G*.

The core idea of this proposal is that, when we qualify a subject, such as *ravens* to yield something like *albino raven*, we piggyback on the mechanism(s) that make a raven normal. A mechanism is eligible to make an albino raven normal just in case it's as much like the one that makes a raven normal as possible, given that the mechanism is one that involves an albino raven.

This proposal serves to explain, for example, why an albino raven that's been painted black does not count as a normally colored albino raven. The mechanism that makes a non-albino raven normally colored excludes the application of paint. And because there is another mechanism that leads to an albino raven having a color, namely one that doesn't involve painting, the mechanism that does involve painting is not as much like the mechanism that makes ordinary ravens normal. The proposal also explains why we cannot assign determinate

truth-conditions to cp-generalizations where the subject is qualified by *abnormal*. If all we know about a raven, say, is that it is abnormal, we don't know which of the very many mechanisms that are slightly different from the ones that make ordinary ravens normal can causally sustain the generalization.

This way of solving the problem is a final payoff from looking very closely at the actual language used to frame cp-generalization. If we tried to state semantics for these generalizations purely in terms of a regimented formal language, we wouldn't be able to discern a difference between the class of ravens and the class of albino ravens. But by taking the connection between cp-generalizations and natural language seriously, we can account for the data.

On the theory I've presented, whether a mechanism that sustains a generalization can qualify the objects involved in it as appropriately normal depends on whether that mechanism bears theoretically important relations to other mechanisms sustaining other generalizations. But which relations are theoretically important depends on the theory and that suggests that when there are different theories that investigate the same target phenomena, different mechanisms count as bearing the theoretically important relations. This prediction of my account is actually borne out.

Dobermans are born with floppy ears. In some countries, including the US, breeders then cut off parts of their ears and temporarily insert posts in order to make the ears grow in a pointy shape. With that information in mind, consider the following texts.

BIOLOGY Some breeds of dogs have evolved to focus on their hearing.

These breeds have pointy ears. Dobermans, however, mostly rely on their sense of smell, and as that fact might lead you to believe, *Dobermans do not have pointy ears*. Dobermans have floppy ears.

DOG-SHOW Welcome to this year's meeting of the Westminster Kennel Club. Some of our breeds have a more relaxed, homely appearance, especially those with floppy ears. Dobermans, however, are regal. Dobermans do not have floppy ears. *Dobermans have*

pointy ears.

In the context of their respective texts, each of the italicized claims is true. That shows that the interpretation of these claims depends on the context in which they are produced. On my account, there is a natural explanation of what is going on. In BIOLOGY, the natural kinds are the kinds of evolution, and any mechanism that involves the actions of breeders fails to be related to other mechanisms in theoretically important ways. By contrast, in DOG-SHOW, we are precisely interested in dog-breeding, and hence the mechanisms that involve (at least some of) the actions of breeders are the ones that contribute to making the property of being a doberman a natural kind property for that theoretical enterprise.

(23) is another example that supports this account.

(23) Sea-turtles are long-lived.

Sea-turtles reproduce by laying their eggs on the beach. They all hatch at the same time, and the newborn turtles have to race to the ocean in order to develop further. On that race to the ocean, most turtles are eaten by predators who are there, awaiting the turtles' appearance. Nonetheless, the mechanism that sustains the generalization focuses on the slow metabolism of turtles and treats the fact of predation as abnormal. This follows naturally from my account, since that mechanism is the result of selection—whether it actually comes to fruition in most turtles or merely a minority is irrelevant. Let me emphasize that not only is the truth of (23) compatible with my account, my account is also compatible with the truth of (24).

(24) Sea-turtles lay many eggs.

Because sea-turtles suffer so heavily from predation, they “plan” for the culling right after birth by laying very many eggs. The mechanism that sustains this generalization plausibly bears the same theoretically important relation to other mechanisms involving turtles as does the mechanism that sustains (23).

The example illustrates several important points. First, one might have responded to the doberman-example by saying that what accounts for the difference in truth-value is simply the salience of dobermans with the relevant shape of ears. Somehow, because we picture a doberman with floppy ears, we find *dobermans don't have pointy ears* to be acceptable in the context of BIOLOGY. But such psychological or perceptual salience cannot account for what happens in (23), since even standing at the beach looking out at the turtles being eaten, we still find (23) acceptable, and *sea-turtles die young* to be false.

Second, the example speaks against an alternative theory of what makes a causal mechanism eligible to underwrite a causally sustained characterizing sentence. One might have said that, in the context of a particular discipline, a causal mechanism is eligible to so underwrite a generalization if it is the kind of mechanism studied in the discipline, and/or it has important effects on the targets of inquiry in that discipline. However, the predator/prey interaction that causes so many young turtles to die satisfies both of these conditions, and still isn't eligible. Clearly, predator/prey interactions are part of what is studied in evolutionary biology, so it's the right kind of mechanism. And such predator/prey interactions also have important effects—for example, they influence how many eggs are laid. By contrast, my account deals with this example neatly, because the slow metabolism of turtles that causally sustains the generalization (23) is related to other mechanisms that underwrite other characterizing sentences by being an adaptation.

5. Conclusions

I have offered a new account of how cp-laws fit into the theoretical aims and demands of the special sciences. To find a class of cp-laws that are properly treated together, I've appealed to broadly linguistic considerations. I've argued that some cp-laws are most naturally stated by the use of characterizing sentences, and that these sentences should be interpreted in terms of a notion of normality. I then argued that such a notion of normality can be defined, albeit non-reductively, by developing resources via consideration of natural kinds in the special

sciences. One point I want to draw attention to is that the claims I've made about natural kinds in the special sciences are very weak. Thus, my account should be acceptable to theorists with quite different commitments.

Let me finish by raising two questions. The first is how to extend this treatment to other cp-generalizations, especially ones that are stated by using habituals, among which there are many ascriptions of dispositions. The second is how this treatment of characterizing sentences can be extended to non-scientific contexts. We obviously make use of characterizing sentences outside of formal scientific inquiry. My semantics suggest that, even in these contexts, we should somehow have the resources to interpret a notion of normality with the structure I identified. It is an open question what psychological and epistemological mechanisms underlie this possibility in the informal context of everyday life.⁴²

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